



Increased Savings with Screened and Shielding Cabling

- The Hidden Costs of Category 6A UTP Systems

While UTP copper cabling systems have been the de facto norm for years in many markets, screened and fully shielded solutions have maintained a stronghold in others. With the increase in bandwidth to 10 Gb/s transmission, the overall channel length allowed by the standards for 10 Gb/s transmission has decreased in legacy category 6 installations, while the overall cable diameter for augmented category 6 (6A) UTP systems has increased. When looking at installation costs for UTP systems, the proper cost calculations should include not only the cable and components, but also the pathways and spaces through which the cable will be routed.

A Brief Word About the Standards

In 10 Gb/s transmissions, alien crosstalk, defined as cable-to-cable noise, is a major disturber to a system. If you strip back a portion of the sheath on a twisted-pair cable, you will notice that each pair has a different twist rate. These varying twist rates reduce interference generated by coupled noise between pairs within the sheath. However, if you have several channels of cable run side by side, the pairs of like color (for instance blue/white) will have the same twist lay as the same pair in the adjacent cable. At higher frequencies, these pairs will interfere with each other through what is called alien crosstalk. As this phenomenon cannot be truly modeled and subsequently cannot be cancelled via active equipment processing, it must be mitigated by cable design and installation practices.

Cable that is approved for 10 Gb/s transmission includes up to 55 meters of category 6 (with installation mitigation techniques), 100m of augmented category 6 UTP or F/UTP (screened) and 100m of S/FTP (fully-shielded) category 7/class F. Augmented category 6 UTP cabling has an overall allowable diameter of 0.354 in. (9.0mm). This contrasts to category 6 cabling, which has an overall diameter of 0.250 in. (6.35mm). In between the two are category 7/class F and F/UTP augmented category 6 systems which have an average diameter of 0.330 in. (8.38mm) and 0.265 in. (6.73mm) respectively. While this does not appear to be a large difference in diameter, it creates a significant difference in large installations where pathways and spaces are concerned.

In order to support 10Gb/s over 55m with a category 6 system, there are several methods addressed in TIA TSB-155 to mitigate alien crosstalk. These include switching to shielded patch cords, unbundling cables in the first and last 15m of the cabling channel, providing port separation for energized ports (i.e.: only allowing odd number ports to be energized to 10 Gb/s) and other methods. This creates additional labor and the possibility of increased material costs to achieve the same transmission performance as the higher performing systems. Where category 6 channels already exist, any channel over 180 ft. (55m) that cannot be mitigated for alien crosstalk will have to be replaced, increasing the overall total cost of ownership of the original system.

In both TIA and ISO standards, the alien crosstalk mitigation steps are essentially the same and require the same costly component - labor. In many cases, both would call for a change in connectors, patch panels and cross-connect fields, increasing labor as well as material costs. It is important to note that augmented category 6A cables utilize a larger diameter that increases the separation between individual pairs in other cables to reduce alien crosstalk. Screened (F/UTP) and fully shielded (S/FTP) systems prevent alien crosstalk through their cable shield. While the highest performance and lowest cost of ownership belongs to category 7/class F, which does not require costly mitigation steps and provides a longer lifecycle through its ability to support applications beyond 10Gb/s, some companies still have a preference to either keep their existing category 6 plant, or use unshielded systems. In order to effectively evaluate the various systems, a total cost of ownership analysis should be performed to determine the additional costs of not only labor, but also the costs of preparing pathways and spaces. In particular, UTP, F/UTP and S/FTP systems will be examined with their pathways and spaces.

Fill Ratios

A fill ratio equates to the amount of cabling that can be run in a pathway or space. In order to preserve warranties on fire-stopping materials and to reduce the effect of alien crosstalk, these ratios must be maintained according to the standards. For larger cabling diameters such as those allowed in augmented category 6 UTP designs, the number of cables permitted in a particular space will decrease and in many cases, larger pathways and spaces will be required. In some jurisdictions where all cabling must be run in conduit due to code, this can increase initial construction and retrofit costs significantly. For areas in office walls where pathways must be provided, larger conduit sizes would be needed for the newer 6A UTP systems.

Conduit Trade sizes and areas are shown in the table to follow.

SAE Measurements			Metric Measurements		
Trade Size	Internal Diameter (in)	Area (in ²)	Metric Designator	Internal Diameter (mm)	Area (mm ²)
1/2	0.62	0.30	16	15.7	193
3/4	0.82	0.53	21	20.8	340
1	1.05	0.86	27	26.7	560
1 1/2	1.61	2.04	41	40.9	1313
2	2.07	3.36	53	52.6	2172
2 1/2	2.47	4.79	63	62.7	3086
3	3.07	7.38	78	80	5024
3 1/2	3.55	9.90	91	90.2	6387
4	4.04	12.72	103	102.4	8231

Table 1: Conduit Trade sizes and areas

Conduit size is expressed by trade size in either inches or millimeters. The area is the inside area that can be occupied by cable. It is recommended that a 40% fill ratio be used for the initial runs to accommodate any room for new runs that would be needed in the future. The formula for calculating fill ratio is as follows:

$$\text{fill ratio} = \frac{(\# \text{ cables}) \times \text{cable cross-sectional area}}{\text{inside cross-sectional conduit area}}$$

$$\text{cable cross-sectional area} = (\varnothing/2)^2 \times 3.14 \text{ where } \varnothing = \text{outside cable diameter}$$

$$\text{inside cross-sectional conduit area} = (\varnothing/2)^2 \times 3.14 \text{ where } \varnothing = \text{inside conduit diameter}$$

Conduit bends must also be factored in and directly affect conduit capacity. A derating factor of 15% should be included for each bend to ensure that pulling tension is not significantly affected. As a result, a conduit run with a 40% fill and 3 bends would be limited to a calculated capacity of:

$$100\% - 15\% - 15\% - 15\% = 55\% ; 40\% \text{ fill} \times 55\% \text{ capacity} = 22\% \text{ available fill ratio}$$

Using a trade size 3/4 (metric designator 21) for this conduit example, 2 category 6 UTP cables with a typical diameter of 0.25 in. (6.35mm) could be placed in the conduit. A category 6A UTP cable, with a diameter of 0.35 in. (9.0mm) would decrease conduit fill to a single cable.

An average 50 ft. (15.2m) run 3/4 EMT conduit including labor and wood bores, 3 bends and a national average labor rate of \$33.86 per hour, would cost \$903.63. Pricing is based on the Craftsman National Estimator. To accommodate two larger diameter category 6A UTP cables, one would need to increase the trade size to 1.0 in. (25mm) conduit. The cost for labor and materials in a 1.0 in. (25mm) trade size is \$1163.62 for the same 50 ft (15.2m) run. The increase in conduit diameter and labor is not needed for augmented category 6 F/UTP. These figures do not include cabling or connectivity, but rather the conduit only. In short, for each work area, an incremental cost of \$259.99 is necessary to accommodate the increased diameter of a category 6A UTP cabling channel in the pathway. An average network has 1000 drops, increasing construction costs by \$259,990.00. Again, this does not include cabling and connectivity.

Including cabling and connectivity materials for the same 50 ft. (15.2m) runs (based on 2 drops per work area, average plenum cable pricing, full retail) the following chart shows the savings based on a 1000 node network with two drops per work area location. Channel pricing includes the patch panel, work area outlet, installation/termination labor and a 3-meter patch cord at each end.

	Cabling/ Connectivity Installation	Conduit Installation	Total Per Channel	Total for 1000 Drops
Category 6A UTP	\$285.68	\$1,163.82	\$1,449.50	\$1,449,500.00
Category 6A F/UTP	\$356.34	\$903.63	\$1,259.97	\$1,259,970.00
Category 7/Class F	\$468.96	\$1,163.82	\$1,632.78	\$1,632,780.00

Table 2: 50 ft. (15.2m) channels

It is clear to see that pathways and spaces become a significant factor in overall infrastructure cost. Category 6A F/UTP provides a project savings of \$169,010.00 over its UTP counterpart. Note: Plenum cable may not be required if the cabling is encased in conduit. Consult local codes for requirements. While the total dollars may change due to non-plenum pricing, this would translate to all channels, not the pathways. It is also clear to see that category 7/class F is roughly equal to that of category 6A when pathways are considered. However category 7/class F systems provide an application upgrade path beyond 10Gb/s.

In areas where conduit is not used and pathways consist of cable tray, ladder rack and/or J-hooks, the same level of increase in pathway space should be factored into overall installation costs. Cable tray is typically recommended to have a 50% fill ratio and ladder rack size is based on cable diameter and

weight with specs varying by manufacturer. The same applies to J-hooks. Beyond facility spaces, the capacity of existing wire management in racks may need to be increased as well.

Another benefit to category 7/class F systems such as Siemon's TERA® is the ability to run multiple applications over the same channel, commonly referred to as cable sharing. Two TERA channels can provide a 4-pair high-speed application and any combination of 1 and 2-pair applications from the chart below. Cable sharing is facilitated by 1 and 2-pair patch cords (not to be confused with splitting pairs behind the faceplate into separate outlets). This ability further maximizes pathway space by combining multiple applications over a single 4-pair cable, versus running individual 4-pair cables for each application.

A Word About Grounding

Gigabit Applications (4-Pair)	10/100 Applications (2-pair)	1-Pair Applications
Gigabit PC	Workstation	Phone (analog voice)
Gigabit Switch Port	Print Server	Video Camera (CCTV)
	Wireless Access Point	
	VoIP Phone	
	Network Printer	
	IP Camera	
	Monitoring Phone	
	Blade Server Port	
	Network Jack/Intellijack	

Table 3: Applications and pair usage

While the cost savings presented by a screened or fully shielded system may be significant, the prospect of installing a system that needs additional grounding steps may cause some concern in markets where UTP cable is the primary media.

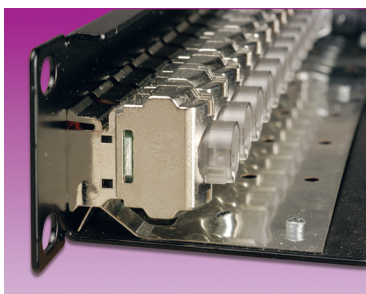


Figure 1: Integrated connector grounding

In the old IBM Type-1 cabling days, many systems were ungrounded, improperly grounded or grounded to different points within a network. Today, the old mysteries surrounding grounding are solved. Newer shielded and screened connectors automatically terminate the cable shield during termination, without additional steps. The connectors are then snapped into a patch panel where they make contact with an integral grounding bar. There is a single grounding lug connection on the back of the patch panel that terminates to the Telecommunications Grounding Busbar (TGB) that should already exist.

Most of the newer active electronics require both chassis and electrical grounds. Ladder rack, cable tray and other components are also required to be connected to a ground/bond.

Today, standards exist (ANSI-J-STD- 607) for grounding and with newer connectivity self-terminating the ground from many outlets to a single point, the costs and complexity of grounding these systems is greatly reduced.

Screened and shielded systems may not be as foreign as people think. If you look at your active electronics, they are all shielded. The shield that surrounds each port on a switch, router or network interface card is there because the active electronics manufacturers have known for years that grounding decreases complexity and noise related issues in their components. Apprehensions of the past should be eliminated.

Summary

Regardless of your labor rates or which standards you follow, screened and fully shielded systems can provide a significant cost benefit while allowing increased bandwidth and application speeds. In any system, the cabling is a minor portion of the overall network. Increased pathway and space cost, along with mitigation costs for existing category 6 systems can negate any savings realized on cabling components. The additional pathway spaces can cause a category 6A UTP system to be more expensive than category 6A F/UTP systems. Retrofit situations will benefit most from a screened category 6A system due to the smaller cable diameter.

Grounding/bonding/earthing is a very easy task when done properly and is really just an additional connection to a grounding system that should already exist. Selection of your cabling system, of course, will depend on your preferences, but bear in mind, the goal is to have a system that will function for 10-20 years depending on your network needs, and every time the systems are revisited, the total cost of ownership increases, in particular where labor is added and re-added.

Consisting of 10G 6A UTP and F/UTP solutions, as well as Category 7/Class F TERA (S/FTP), Siemon's 10G ip family of copper cabling products represents the most comprehensive line of end-to end 10Gb/s capable solutions available. The entire Siemon 10G ip line meets or exceeds all requirements under the pending 10GBASE-T standards, including alien crosstalk. For a complete description of all systems, please visit www.siemon.com.

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